# 3. THE GREAT LAKES

(1) **The Great Lakes system** includes Lakes Ontario, Erie, Huron, Michigan, and Superior, their connecting waters, and the St. Lawrence River. It is one of the largest concentrations of fresh water on the earth. The system, including the St. Lawrence River above Iroquois Dam, has a total shoreline of about 11,000 statute miles (9,559 nm), a total water surface area of about 95,000 square statute miles (24,600,000 hectares), and a total drainage basin of almost 300,000 square statute miles (77,700,000 hectares). With the opening of the St. Lawrence Seaway, the system provides access by oceangoing deep-draft vessels to the great industrial and agricultural heartland of the North American continent. From the Strait of Belle Isle at the mouth of the Gulf of St. Lawrence, the distance via the St. Lawrence River to Duluth, MN, at the head of Lake Superior is about 2,340 statute miles (2,033 nm) and to Chicago, IL, near the S end of Lake Michigan is about 2,250 statute miles (1,955 nm). About 1,000 statute miles (870 nm) of each of these distances is below Montreal, the head of deep-draft ocean navigation on the St. Lawrence River.

(2) Small craft and barge traffic may also reach the Great Lakes via two shallow-draft routes; from the Gulf of Mexico via the Mississippi River and the Illinois Waterway to Lake Michigan at Chicago, IL, a distance of about 1,530 statute miles (1,329.5 nm), and from New York Harbor via the Hudson River and the New York State Barge Canal System to Lake Ontario at Oswego, N.Y., a distance of 340 statute miles (295.5 nm), or to the Niagara River at Tonawanda, N.Y., a distance of 496 statute miles (431 nm).

(3) The following table shows the controlling dimensions for these three routes and for other canals within the Great Lakes system.

(4) **The following limiting dimensions in feet (meters) are for each of the three routes described above and for canal navigation in the Great Lakes system:**

(5) ***St. Lawrence River**–

(6) depth, 26 feet (7.9 meters);

(7) width, 76 feet (23.16 meters);

(8) length, 730 feet (222.5 meters), 740 feet (225.5 meters) when certain conditions are met;

(9) vertical clearance, 117 feet (35.6 meters).

(10) **Mississippi River-Illinois Waterway**–

(11) depth, 9 feet (2.7 meters);

(12) width, 80 feet (24.38 meters);

(13) length, 600 feet (182.88 meters);

(14) vertical clearance, 17 feet (5.18 meters).

(15) **N.Y. State Canals-Hudson River to Oswego**–

(16) depth, 13 feet (4 meters);

(17) width, 43.5 (13.2 meters);

(18) length, 300 feet (91.4 meters);

(19) vertical clearance, 20 feet (6.1 meters).

(20) **Hudson River to Whitehall, and from Three Rivers to Ithaca, Montour Falls, and Tonawanda**–

(21) depth, 12 feet (3.66 meters);

(22) width, 43.5 feet (13.2 meters);

(23) length, 300 feet (91.4 meters);

(24) vertical clearance, 15.5 feet (4.7 meters).

(25) **Riviere Richelieu-Lake Champlain to St. Lawrence River**–

(26) depth, 6 feet (1.8 meters);

(27) width, 23.2 feet (7.07 meters);

(28) length, 111.4 feet (33.8 meters);

(29) vertical clearance, 29 feet (8.8 meters).

(30) ***Welland Canal**–

(31) depth, 26 feet (7.9 meters);

(32) width, 76 feet (23.16 meters);

(33) length, 730 feet ( 222.5 meters), 740 feet (225.5 meters) when certain conditions are met;

(34) vertical clearance, 117 feet (35.66 meters).

(35) **St. Marys Falls Canal (Soo Locks)**–(See Limiting Dimensions of Through Channel, chapter 12, St. Marys River.)

(36) *Minimum limiting measurements for transit of the entire Seaway by pleasure craft are a deadweight of 1 short ton (0.9 metric ton) or 20 feet (6.1 meters) in overall length. These control factors are based on requirements for passage through the South Shore Canal, Beauharnois Canal, and the Welland Canal.

(37) The **St. Lawrence Seaway** includes the waters of the St. Lawrence River above Montreal, Lake Ontario, the Welland Canal, and Lake Erie as far W as Long Point. The canals and locks of the Seaway overcome the rapids and water level differences in the St. Lawrence River between the ocean and Lake Ontario and between Lake Ontario and Lake Erie and enable deep-draft oceangoing vessels to proceed from the Atlantic Ocean to Lake Superior, the farthest inland major lake. The development, operation, and maintenance of the Seaway are under the joint control of The **Saint Lawrence Seaway Development Corporation,** a corporate agency of the United States, and The **St. Lawrence Seaway Management Corporation of Canada**. The Corporation headquarters is in Washington, D.C., and the operational field headquarters is in Massena, N.Y. The Canadian Corporation headquarters is in Cornwall, Ont., with field offices in Cornwall, St. Lambert, and St. Catharines. (See appendix for addresses.)

(38) The United States and Canadian Corporations jointly publish the **Seaway Handbook,** which contains regulations issued by the respective governments and other information relating to operational requirements of vessels transiting the Seaway. The Handbook also contains a schedule of Seaway tolls. The regulations contained in the Handbook are also codified in 33 CFR 401. A copy of the regulations is required to be kept on board every vessel transiting the Seaway. (See **33 CFR 401**, chapter 2.)

(39) The Corporations each issue **Seaway Notices,** which contain information on changes in aids to navigation and other information relating to safety of navigation in the Seaway. The information contained in the notices is also broadcast by Seaway radio stations. The Seaway Notices are available at appropriate locks and canals and at the offices of the Seaway entities.

(40) Aids to navigation in U.S. waters of the Seaway between St. Regis and the head of the St. Lawrence River are operated and maintained by The Saint Lawrence Seaway Development Corporation and are described in the U.S. Coast Guard Light List. Buoys off station, lights extinguished or malfunctioning, and other defective conditions should be reported promptly, by radio or other means, to the nearest Coast Guard unit or to Massena traffic control center via "Seaway Eisenhower" or "Seaway Clayton."

(41) **Vessel Traffic Services.**–A Vessel Traffic Service (VTS) has been established in St. Marys River. The Service has been established to prevent collisions and groundings, to protect

improvements to the waterway, and to protect the navigable waters from environmental harm.

(42) The Vessel Traffic Service provides for a Vessel Traffic Center (VTC), voice call, “Soo Control,” that may regulate the routing and movement of vessels by movement reports of vessels, specific reporting points, and VHF-FM radio communications. The Service includes one- and two-way traffic areas, areas of allowed and prohibited anchorage, and speed limits.

(43) Participation in the Vessel Traffic Service (St. Marys River) is mandatory. (See **33 CFR 161.801 through 161.894,** chapter 2, for regulations affecting vessel operations in the Vessel Traffic Service, and chapter 12 for details.)

(44) The Canadian Coast Guard operates a **Vessel Traffic Service (VTS)** in Canadian waters from Long Point in Lake Erie through the Detroit and St.Clair Rivers to De Tour Reef Light in Lake Huron. The service is mandatory from Detroit River East Outer Channel Lighted Buoy 1 and West Outer Channel Lighted Bell Buoy 1 to a point 30 minutes N of Lake Huron Cut Lighted Horn Buoy 11. The service is voluntary in the remaining waters. The service is designed to enhance the safe and expeditious movement of marine traffic by encouraging the monitoring of a common radio frequency by vessels within each sector of the service. The service provides users with information on traffic situations pertaining to no meeting zones, as well as information to pilots, the St. Lawrence Seaway Authority, the public, vessel owners, and shipping agents.

(45) The service is divided into two traffic sectors, each with a specific operating frequency: **Sector 1,** VHF-FM channel 11, the Canadian waters from De Tour Reef Light to Lake St. Clair Light in Lake St. Clair; and **Sector 2**, VHF-FM channel 12, the Canadian waters from Lake St. Clair Light to Long Point Light in Lake Erie.

(46) The VTS is administered by the VTS Center at Sarnia, Ont., at the head of the St. Clair River. The center is equipped with VHF transmitting and receiving facilities both locally and from remote sites. Participating vessels should report their name and ETA at the next calling-in point to the VTS Center and, on request, will receive all reported information on vessel traffic in their area. In the voluntary participation areas of the VTS, calling-in points are located in Lake Erie abeam Long Point Light and abeam Southeast Shoal Light and in Lake Huron abeam Harbor Beach Light or Point Clark Light, abeam Cove Island Light, abeam Great Duck Island Light, and abeam De Tour Reef Light. A voluntary calling-in point is within the mandatory area of the VTS at Lake Huron Cut Lighted Buoy 11. Calling-in points in the mandatory participation areas of the VTS are identical to those of the U.S. Coast Guard vessel traffic reporting system described in **33 CFR 162.130 through 162.140** (see chapter 2). (For complete information on the VTS, including calling-in points and message content, refer to the Annual Edition of Canadian Notices to Mariners.)

(47) Mariners are cautioned that not all vessels navigating in the voluntary areas of the service may be participating. The service is in no way an attempt by the Canadian Coast Guard to regulate the navigation or maneuvering of vessels from a shore station. The VTS does not override the responsibility of the master for the safe navigation of his vessel in accordance with the Navigation Rules.

(48) **Navigation regulations.**–The U.S. Coast Guard has established a **vessel traffic reporting system** and related navigation regulations for the connecting waters from Lake Erie to Lake Huron. The reporting system is operated through the Canadian Vessel Traffic Service Center at Sarnia, Ont. (See **33 CFR 162.130 through 162.140,** chapter 2, for complete information.)

(49) **Vessel Traffic Management.**–A Vessel Traffic Management Contingency Plan (VTM) for the Detroit and St. Clair Rivers has been agreed upon by the United States Coast Guard and the Canadian Department of Transport. The purpose of the system is to enhance the safety of navigation in the rivers during periods of exceptionally hazardous navigation conditions and to protect the navigable waters of the rivers from environmental harm. These objectives are accomplished by establishing criteria for allowing vessels to transit the system, by managing vessel entries and transits of the system, and by establishing no passing zones as required. The system is implemented only in cases of emergency, upon agreement of the Commander, U.S. Coast Guard Ninth District, and the Director, Central Region, Canadian Department of Transport. The implementation will be promulgated through Broadcast Notice to Mariners.

(50) This VTM system applies to all vessels 65 feet (19.8 meters) or over in length, all commercial vessels 26 feet (7.9 meters) or over in length when engaged in towing another vessel astern, alongside, or by pushing ahead, and each dredge or floating plant operating in the VTM area. Vessels in Sector 1 of the system, the Detroit River and Lake St. Clair S of Lake St. Clair Light, shall communicate with Detroit Vessel Traffic Center on VHF-FM channel 12. Vessels in Sector 2, Lake St. Clair N of Lake St. Clair Light and St. Clair River, shall communicate with Sarnia Vessel Traffic Center on VHF-FM channel 11. The secondary communications frequency for both sectors is VHF-FM channel 16.

(51) **Ports and Waterways Safety.–**(See **33 CFR 160,** chapter 2, for regulations governing vessel operations and requirements for notifications of arrivals, departures, hazardous conditions, and certain dangerous cargoes to the Captain of the Port.)

(52) **Disposal Sites** and **Dumping Grounds.**–These areas are rarely mentioned in the Coast Pilot, but are shown on the nautical charts. (See Dump Sites and Dumping Grounds, chapter 1, and charts for limits.)

(53) **Ballast Water Management.–** Vessels are required to carry out an exchange of ballast water on the waters beyond the EEZ prior to entry into Snell Lock, at Massena, NY. (See **33 CFR 151.1502 through 151.1516,** chapter 2, for regulations.)

(54) **Potable Water Intakes.**–Vessels operating on freshwater lakes or rivers including the Great Lakes and connecting waters shall not discharge sewage, ballast, or bilge water, within the restricted areas adjacent to potable water intakes as are designated by the Surgeon General of the United States. (See **21 CFR 1250.93,** chapter 2.)

(55) **Note.**–This regulation, originally published under Title 42, Public Health, by the U.S. Public Health Service, is published in Title 21, Food and Drugs; cognizant agency, Food and Drug Administration.

(56) The current list of restricted vessel waste discharge areas adjacent to potable (domestic) water intakes is contained in the Federal Register of September 16, 1960 (25 F.R. 8925). The areas were described and located by both geographical coordinates and by NOS Chart Numbers.

(57) Except as otherwise specifically indicated in the above list, in each case the restricted area includes the water within a circle having a radius of 3 statue miles (2.6 nm) with the domestic

water intake as its center, in no event, however, extending beyond the International boundary line with Canada.

(58) This restriction applies to all vessels which are underway, moored, or anchored within the restricted areas subject to the following provisions:

(59) 1. Vessels moored at docks shall not discharge sewage, ballast or bilge water overboard if dock facilities for the disposal of such waste are available.

(60) 2. Vessels required to anchor within a restricted area under an emergency condition for the safety of the vessel are exempted.

(61) 3. Vessels which provide sewage or waste treatment approved by the . . . (Commissioner of Food and Drugs), are exempted from that portion of the restriction applicable to sewage.

(62) The list of intakes and the extent of the restricted areas may be revised from time to time.

(63) **Danger zones** have been established within the area of this Coast Pilot. (See **33 CFR 334,** chapter 2, for limits and regulations.)

(64) **Drawbridges**.–The general regulations that apply to all drawbridges are given in **117.1 through 117.49**, chapter 2, and the specific regulations that apply only to certain drawbridges are given in **Part 117, Subpart B**, chapter 2. Where these regulations apply, references to them are made in the Coast Pilot under the name of the bridge or the waterway over which the bridge crosses.

(65) The drawbridge opening signals (see **117.15**, chapter 2) have been standardized for most drawbridges within the United States. The opening signals for those few bridges that are nonstandard are given in the specific drawbridge regulations. The specific regulations also address matters such as restricted operating hours and required advance notice for openings.

(66) The mariner should be acquainted with the general and specific regulations for drawbridges over waterways to be transited.

(67) **Fluctuations of water level.**–The water levels of the Great Lakes are subject to three types of fluctuation: seasonal, long range, and short period. Seasonal or annual fluctuations cover a period of about 1 year, long range fluctuations a few or many years, and short period fluctuations from several minutes to a few days. Seasonal and long range fluctuations generally affect an entire lake, while short period fluctuations are local in scope.

(68) The seasonal fluctuations are the most regular, with the highest levels usually occurring in summer and the lowest in winter. These fluctuations are caused by a number of factors that affect lake levels, including rain and snowfall, evaporation, ground water levels, and runoff from the land. From year to year, the magnitude of the fluctuation between the high and the low and the months in which these occur may vary considerably in an individual lake. Lake Superior is generally last to reach its seasonal low and seasonal high, in March and September, respectively. Lakes Michigan and Huron usually reach their low in February and their high in July. Lake Erie usually reaches its low in February and its high in June. Lake Ontario usually reaches its low in January and its high in June. The amount of fluctuation between the seasonal high and low is generally least in Lake Superior and most in Lake Ontario.

(69) Long range fluctuations of the lake levels are caused by long term variations of the same factors which affect seasonal fluctuations. Precipitation is the most important of these factors. Long periods of above or below normal rain and snowfall are usually followed by higher or lower lake levels, but this effect may be increased or decreased by combination with the other factors that affect lake level. Another cause of long range fluctuations is the uplifting of the earth's crust in the Great Lakes region. When the outlet of the lake is rising in relation to the lake shores, the water level rises with respect to the land. This effect is occurring in all the lakes, except for parts of the NE shores of Lake Superior and Lake Huron.

(70) Short period fluctuations occur in amounts varying from a few inches to several feet and for periods varying from a few minutes to a day, depending on the locality where they occur. These fluctuations are caused by winds, by sudden barometric pressure changes, and by oscillations called seiches, which may be caused by one or both of the other two. Sustained winds drive forward a greater volume of surface water than can be carried off by the subsurface return currents, thus raising the water level on the lee shore and lowering it on the windward shore. This effect is more pronounced in bays and at the extremities of the lakes, where the impelled water is concentrated in a small space by converging shores, especially if coupled with a gradually sloping inshore bottom which even further reduces the flow of the lower return currents. Closely spaced high and low barometric pressure centers moving across a lake cause a temporary tilting of the water surface. The amount of this tilting is dependent on the pressure gradient and the speed of the moving centers. **Seiche** (pronounced saych) is an oscillation that occurs when winds and/or barometric pressure differences causing a fluctuation have diminished. The lake surface is in a tilted condition, and a surge of water takes place from the high area to the low. An imbalance in the opposite direction occurs and causes a return surge. This effect continues, with each successive surge diminished by friction until the seiching action ceases.

(71) Lunar tides are known to exist on the Great Lakes, particularly on those lakes with an E and W axis. However, the effects of these tides are so small as to be inconsequential when compared to the effects of other short period fluctuations. (See the appendix for a list of water level publications published by NOS and the Corps of Engineers.)

(72) **Weather, The Great Lakes.**–This section presents an overall, seasonal picture of the weather that can be expected in the Great Lakes region of the United States. Detailed information, particularly concerning navigational weather hazards, can be found in the weather articles in the following chapters.

(73) All weather articles in this volume are the product of the National Oceanographic Data Center (NODC) and the National Climatic Data Center (NCDC). The meteorological and climatological tables are the product of the NCDC. Both centers are entities of the National Environmental Satellite, Data, and Information Service (NESDIS) of the National Oceanic and Atmospheric Administration (NOAA). If further information is needed in relation to the content of the weather articles, meteorological tables or climatological tables, contact the National Climatic Data Center, Attn: Customer Service Division, Federal Building, 151 Patton Avenue, Room 120, Asheville, NC 28801-5001. You may also contact the CSD at 704-271-4994, or fax your request to 704-271-4876.

(74) Climatological tables for lakeshore and near-lakeshore locations, and meteorological tables for select lake areas follow the appendix. The climatological tables are a special extraction from

the International Station Meteorological Climate Summary. The ISMCS is a CD-ROM jointly produced by the National Climatic Data Center, Fleet Numerical Meteorology and Oceanography Detachment-Asheville, and the U.S. Air Force Environmental Technical Applications Center, Operating Location - A. The meteorological tables for the lake areas are compiled from observations made by ships in passage and extracted from the National Climatic Data Center's Tape Deck-1129, Surface Marine Observations. Listed in the appendix are National Weather Service offices and radio stations which transmit weather information.

(75) Marine Weather Services Charts published by the National Weather Service show radio stations that transmit marine weather broadcasts and additional information of interest to mariners. These charts are for sale by the National Ocean Service Distribution Division (N/ACC3). (See appendix for address.)

(76) Weather can make navigating the Great Lakes a pleasure, a challenge, or a terror. Each season has its own weather problems, each waterway its own peculiarities.

(77) Winter navigation is severely restricted by ice and storms. Ice coverage and thickness vary from lake to lake and season to season. Seaway shipping is usually at a standstill from mid-December through early April. Great Lakes shipping extends into the winter but depends upon local conditions. The ice threat is compounded by fierce winter storms which bring a variety of wind, wave, and weather problems on an average of every 4 days. A combination of strong winds, rough seas, and cold temperatures can result in superstructure icing, in which sea spray and sometimes precipitation can freeze to a ship's superstructure. This adds tremendous weight and creates dangerous instability.

(78) Spring storms can generate gales and rough seas, but with the approach of summer they become less frequent and severe. Fog is the principal navigational headache. Relatively warm air pumped over still cold lake waters creates an advection fog that plagues the mariner into the summer. In late spring, thunderstorms become an occasional problem.

(79) While fog can hinder navigation and an occasional low-pressure system can bring a spell of bad weather, this is usually the most troublefree time. The principal threat is the thunderstorm. While they can occur in any month, they are most likely from May through October. They can spring up quickly and generate strong winds and rough seas.

(80) Autumn is dangerous. Clear, crisp days are often interrupted by rapidly intensifying low-pressure systems whose gale-force winds can whip tumultuous seas. Energy is supplied by the still warm waters, and contrasting air masses can spawn storms right over the Great Lakes Basin. Occasionally, an errant tropical cyclone makes its way into the region. Fog can be a local, generally nearshore, problem on calm, clear nights. It usually lifts shortly after sunrise.

(81) **Extratropical Cyclones.**–The Great Lakes lie in the midst of a climatological battlefield, where northern polar air often struggles for control with air from the Tropics. During spring and autumn, the zone separating these two armies lies over the Lakes region. The contrast between the two triggers the formation of a number of low-pressure systems, often intense, often fast moving. The Lakes provide moisture and, in the fall, heat to fuel these winter-type storms. They also aid storms that migrate from other regions.

(82) The more destructive storms usually come from the SW or W. Lows spawned in the Pacific southwest, Arizona-New Mexico, and the central Rocky Mountain and Great Plains States account for nearly half of the storms that enter the Great Lakes Basin from October through May. Another source is western Canada, which spawns the **"Alberta Lows."** At a peak in October, these storms arrive from the W and NW. They are relatively weak and rarely generate gales; however, occasionally one has been known to kick up 60-knot winds after intensifying over friendly waters.

(83) When a ship is S of an eastward-moving storm center, the approach of the low is heralded by a falling barometer, a SE to S wind, lowering clouds, and drizzle, rain, or snow. Precipitation diminishes and the wind veers as the warm front nears. In the warm sector, temperatures rise, skies brighten, and the air is humid with haze or fog. The passage of the cold front is marked by a bank of convective clouds to the W, a sharp veering of the wind to the W or NW, and sometimes sudden squalls with showers or thunderstorms. Behind the cold front, pressure rises, temperatures fall, visibility increases, and cloud cover decreases.

(84) When a ship is N of the storm center, changes in the weather are less rapid and less distinctive than when sailing S of the center. Winds ahead of the low gradually back from the E through N to NW. The weather conditions also vary, gradually shifting from those found in advance of the warm front to those behind the cold front.

(85) **Tropical Cyclones**.–Each of the Great Lakes, except for Lake Superior, has been effected by tropical cyclones since 1900. The origin for tropical activity in this region may come either from the Gulf of Mexico or the western Atlantic. A total of 33 storms, most in the decaying stages have traversed at least one of the lakes since the turn of the century. Most have completed the extratropical transition either before reaching the lakes or in the proximity and are greatly weakened. A few, most notable Hurricane Hazel in 1954, became a fully cold-core system and was nearly as strong while crossing the region as when making initial landfall hundreds of miles away. Hazel came ashore in southeastern North Carolina packing winds of 110 knots. By the time the storm had reached Lake Ontario 18 hours later, winds were still 70 knots. This strength was maintained while crossing the lake and weakening finally occurred in southern Ontario.

(86) **Thunderstorms.**–While they can develop in any month, thunderstorms are most likely from May through October. They can occur in squall lines or a single cell. They can stir a breeze or kick up gusts of 100 knots. They can spring up rapidly or be tracked for several days. They can bring a gentle shower or harbor a tornado or waterspout. They can create serious problems for the Great Lakes mariner. The number of days with thunderstorms can vary from year to year, but on the average they can be expected on 5 to 10 days per month during the summer. The Lakes themselves can influence this frequency. Cool water and a strong lake breeze both inhibit summertime convective activity over water. For example, Lake Michigan suppresses thunderstorm activity during the summer, but increases it slightly in autumn. Along the shore, activity is most likely in the afternoon and evening, while over open waters it is more likely at night.

(87) **Fog.**–Fog can form in any season, but it is most likely in spring and early summer, particularly over open waters. Along the shore, fog is also common in autumn. Occasionally, steam fog will develop during the winter. The densest and most widespread fog is the advection type, where relatively warm air flows over cooler water. These conditions exist in spring and summer. Fog is particularly tenacious over the NW portions of the lakes, where the cold water is continually brought to the surface by

upwelling. This fog is often persistent. It may lift somewhat during the day, but unless broken up by a good wind, will lower again during the night. Radiation fog is formed by the air in contact with a rapidly cooling land surface, such as occurs on clear, calm autumn nights. This fog forms onshore and may drift out over the lakes during the early morning. It is usually not as dense nor persistent as advection fog and should lift by noon. Steam fog or arctic sea smoke occurs when frigid arctic air moves across the lakes and picks up enough moisture to become saturated. This fog may vary from 5 to 5,000 feet (1 to 1,500 meters) in depth, although it is seldom very dense.

(88) **Ice.**–Ice begins to form slowly, usually in early November, in the shallows, coves, and inlets. Gradually it spreads and thickens, building out from the shore and breaking off. Since during most winters the period of freezing temperatures is not long enough to cause a lakewide solid ice sheet to form, most lakes are besieged by "pack ice," which, in its broadest sense, is any ice that is not fast ice. This pack ice is then susceptible to the whims of winds, waves, and currents. This can cause rapid changes in a real coverage, which make predictions of thickness, extent, and distribution difficult.

(89) The ice that builds out from the shore ranges from a few inches to several feet in thickness. Much of it breaks off to form floes and fields. Strong persistent winds cause windrows and pressure ridges to form. Some of these may extend 10 to 20 feet (3 to 6 meters) above the water and 30 to 35 feet (9 to 11 meters) below, anchoring themselves to the lake bottom. Pack slush ice, which is pack ice that is well broken up, is particularly harzardous to shipping. It is difficult to combat as it quickly closes in around a vessel, preventing movement in any direction. It can damage propellers and steering gear, clog condenser intakes, and exert tremendous pressure on the hull.

(90) Ice is often strong enough to halt navigation through the St. Lawrence Seaway by mid-December. The Seaway usually reopens by mid-April. Inter- and intra-lake shipping usually continues well into January with the help of icebreakers. A few channels remain open all season. Ice cover peaks in late February or early March. Soon the decay begins. By April, shipping is in full swing; however, some drift ice remains into May.

(91) **Cargo Care.**–High humidities and temperature extremes that can be encountered when navigating the Great Lakes may cause sweat damage to cargo. This problem is most likely when cargoes are loaded in warm summer air or can occur anytime temperatures fluctuate rapidly.

(92) When free air has a higher dewpoint than the temperature of the surface with which it comes in contact, the air is often cooled sufficiently below its dewpoint to release moisture. When this happens, condensation will occur aboard ship either on relatively cool cargo or on the ship's structure within the hold, where it drips onto the cargo. If cargo is stowed in a cool climate and the vessel sails into warmer waters, ventilation of the hold with outside air can lead to sweat damage of any moisture-sensitive cargo. Unless the cargo generates internal heat, then, as a rule, external ventilation should be shut off. When a vessel is loaded in a warm weather region and moves into a cooler region, vulnerable cargo should be ventilated.

(93) In general, whenever accurate readings show the outside air has a dewpoint below the dewpoint of the air surrounding the vulnerable cargo, such outside air is capable of removing moisture and ventilation may be started. However, if the outside dewpoint is higher than the dewpoint around the cargo, ventilation will increase moisture and result in sweating. This generally does not take into account the possibility of necessary venting for gases or fumes.

(94) **Optical Phenomena.**–The two basic types of optical phenomena are those associated with electromagnetic displays and those associated with the refraction or diffraction of light. The **aurora** and **Saint Elmo's fire** are electromagnetic displays. Halos, coronas, parhelia, sun pillars, and related effects are optical phenomena associated with the refraction and diffraction of light through suspended cloud particles; mirages, looming, and twilight phenomena such as the "**green flash**" are optical phenomena associated with the refraction of light through air of varying density. Occasionally, sunlight is refracted simultaneously by cloud suspensions and by dense layers of air producing complex symmetric patterns of light around the sun.

(95) A **mirage** is caused by refraction of light rays in a layer of air having rapidly increasing or decreasing density near the surface. A marked decrease in the density of the air with increasing altitude is the cause of such phenomena known as looming, towering, and superior mirages. Looming is said to occur when objects appear to rise above their true elevation. Objects below the horizon may actually be brought into view. Towering has the effect of elongating visible objects in the vertical direction. A superior mirage is so named because of the appearance of an image above the actual object. Ships have been seen with an inverted image above and an upright image floating above that.

(96) Such mirages, especially with looming and towering, are fairly common in the area, with frequency increasing toward the higher latitudes. They are most common in summer when the necessary temperature conditions are most likely. Another type, the inferior mirage, occurs principally over heated land surfaces such as deserts, but may be observed occasionally in shallow coastal waters, where objects are sometimes distorted beyond recognition. In contrast to the superior mirage, the condition necessary for the inferior mirage is an increasing air density with height. Atmospheric zones of varying densities and thicknesses may combine the effects of the various types of mirages to form a complicated mirage system known as **Fata Morgana.**

(97) The green flash is caused by refractive separation of the sun's rays into its spectral components. This may occur at sunrise or sunset when only a small rim of the sun is visible. When refractive conditions are suitable, red, orange, and yellow waves of sunlight are not refracted sufficiently to reach the eye, whereas green waves are. The visual result is a green flash in the surrounding sky.

(98) The refraction of light by ice crystals may result in many varieties of halos and arcs. Because red light is refracted the least, the inner ring of the halo is always red with the other colors of the spectrum following outward. Halos with radii of 22° and 46° have been observed with the refraction angle within the ice spicules determining which type may occur.

(99) Solar and lunar coronas consist of a series of rainbow-colored rings around the sun or moon. Such coronas resemble halos but differ in having a reverse sequence of the spectrum colors, red being the color of the outer ring, and in having smaller and variable radii. This reversed sequence of the spectrum occurs because coronas result from diffraction of light whereas the halo is a refraction phenomenon. The radius varies inversely as the size of the water droplets. Another type of diffraction phenomenon is the **Brocken bow** (also known as **glory**), which consists of

colored rings around shadows projected against fog or cloud droplets.

(100) Ice blink, land blink, and water and land skies are reflection phenomena observed on the underside of cloud surfaces. Ice blink is a white or yellowish-white glare on the clouds above accumulations of ice. Land blink is a yellowish glare observed on the underside of clouds over snow-covered land. Over open water and bared land, the underside of the cloud cover when observed to be relatively dark is known as water sky and land sky. The pattern formed by these reflections on the lower side of the cloud surfaces is known as "sky map."

(101) Auroral displays are prevalent throughout the year, but are observed most frequently in the winter. Records show that the periods of maximum auroral activity coincide in general with the periods of maximum sunspot activity.

(102) The cloudlike, luminous glow is the most common of the auroral forms. The arc generally has a faint, nebulous, whitish appearance and is the most persistent of the auroras. Ray auroras are more spectacular but less persistent phenomena. They are usually characterized by colored streaks of light that vary in color and intensity, depending on altitude. Green is the most commonly observed hue, although red and violet may occur in the same display. The **aurora borealis** (northern lights) may be observed on occasion.

(103) Saint Elmo's fire is observed more rarely than the aurora and may occur anywhere in the troposphere. It occurs when static electricity collects in sufficiently large charges around the tips of pointed objects to ionize the air in its vicinity and leak off in faintly luminescent discharges. Saint Elmo's fire is observed occasionally on ship masts and on airplane wings in the vicinity of severe storms. It is described either as a weird, greenish glow or as thousands of tiny electrical sparks flickering along the sharp edges of discharging surfaces.

(104) **Winter Navigation.**–Ice normally begins to form in various parts of the Great Lakes during December and forms a hazard to navigation by the end of the month. Before the St. Lawrence Seaway closes in late December, most lake vessels lay up for the winter and oceangoing vessels transit the Seaway to the Atlantic. Historically, weather and ice conditions have necessitated the suspension of shipping in the lakes from about mid-December until early April.

(105) During the ice season, U.S. Coast Guard icebreakers, sometimes working in conjunction with Canadian Coast Guard icebreakers, conduct operations to maintain a broken track along the main vessel routes through the lakes, St. Marys River, and the Detroit-St. Clair River system and to assist vessels in transit as necessary. Floating aids to navigation, except those designated in the Coast Guard Light List as winter markers, are withdrawn from service immediately prior to the formation of ice on the lakes.

(106) The Coast Guard operates a VHF-FM radiotelephone vessel traffic reporting system on Lakes Superior, Michigan, Huron, Erie, and the St. Marys River. The system is designed to provide vessel traffic information, aid in the efficient deployment of icebreaking services, and obtain ice information from transiting vessels. Vessels are requested to contact the appropriate Coast Guard Task Group prior to or upon departure from port, upon arrival at their destination, and at specified calling-in points between.

(107) **Routes.**–The Lake Carriers' Association and the Canadian Shipowners Association have recommended, for vessels enrolled in the associations, separation routes for upbound and downbound vessels on the Great Lakes and connecting waterways. These routes are shown on the Great Lakes charts published by the National Ocean Service and are described in this Coast Pilot at the beginning of each affected chapter.

(108) **Pilotage.**–By International agreement between the United States and Canada, the waters of the Great Lakes and the St. Lawrence River have been divided into designated and undesignated waters for pilotage purposes. In designated waters, registered vessels of the United States and foreign vessels are required to have in their service a United States or Canadian registered pilot. In undesignated waters, registered vessels of the United States and foreign vessels are required to have in their service a United States or Canadian registered pilot or other officer qualified for Great Lakes undesignated waters.

(109) The designated waters of the Great Lakes are divided into three districts as follows:

(110) **District 1,** all waters of the St. Lawrence River between the International boundary at St. Regis, Que., and a line at the head of the river running from Carruthers Point Front Range Light, Kingston, Ont., on a bearing of about 127° true through Wolfe Island South Side Light extended to the New York shore;

(111) **District 2,** all waters of Lake Erie W of a line on a bearing of about 026° true from Sandusky Harbor Pierhead Light at Cedar Point, Ohio, to Southeast Shoal Light; the waters contained within the area of a circle of 1 mile radius E of Sandusky Harbor Pierhead Light; the Detroit River; Lake St. Clair; the St. Clair River and the N approaches thereto S of latitude 43°05'30"N.; the Welland Canal which includes waters of the canal in the S approach within an arc drawn 1 mile to the S of the outer light on the W breakwater at Port Colborne, and in the N approach within an arc drawn 1 mile to the N of the W breakwater light at Port Weller; and

(112) **District 3,** all waters of the St. Marys River, Sault Ste. Marie locks, and approaches thereto between latitude 45°59'N. at the S approach and longitude 84°33'W. at the N approach.

(113) Undesignated waters are all waters of the Great Lakes other than designated waters. For purposes of pilotage, Great Lakes means Lakes Superior, Michigan, Huron, Erie, and Ontario, their connecting and tributary waters and the St. Lawrence River above St. Regis, and adjacent port areas.

(114) Oceangoing vessels entering the St. Lawrence River from sea make arrangements for pilotage service in advance through ships' agents. For vessels already on the Great Lakes that require pilotage service, the nearest pilot dispatch office is notified 12 hours ahead with a follow-up confirmation 4 hours in advance.

(115) The various regions of the Great Lakes are served by several associations of United States and Canadian registered pilots. The associations and their service areas are as follows:

(116) Laurentian Pilotage Authority, St. Lawrence River below the lower entrance to St. Lambert Lock at Montreal;

(117) Great Lakes Pilotage Authority, Ltd., Cornwall, and

(118) St. Lawrence Seaway Pilots Association, St. Lawrence River above the lower entrance to St. Lambert Lock at Montreal;

(119) Great Lakes Pilotage Authority, Ltd., St. Catharines, Lake Ontario, Welland Canal, and Lake Erie;

(120) Lakes Pilots Association, Lake Erie, Detroit River, and St. Clair River;

(121) Western Great Lakes Pilots Association, Lake Huron, Lake Michigan, St. Marys River, and Lake Superior. (See appendix for dispatch office addresses and telephone numbers.)

(122) Pilot exchange points are

(123) at St. Lambert Lock at Montreal;

(124) at Beauharnois Lock;

(125) at Snell Lock; off Cape Vincent, N.Y., at the head of the St. Lawrence River;

(126) 1 to 2 statute miles (0.9 to 1.7nm) N of Port Weller;

(127) 1 to 2 statute miles (0.9 to 1.7nm) S of Port Colborne;

(128) just below the Ambassador Bridge in the Detroit River;

(129) off Port Huron at the head of St. Clair River in about 43°05'30"N., 82°24'42"W.;

(130) at De Tour, Mich., at the mouth of St. Marys River; and

(131) at the head of St. Marys River about 3.5 statute miles (about 3 nm) SE of Point Iroquois.

(132) **Towage.**–Tugs are available at most of the major ports; they can usually be obtained for the smaller ports on advance notice if none are available locally. Arrangements for tugs should be made in advance through the ships' agents or the pilots. See the text for the ports concerned as to the availability of tugs.

(133) **Vessel Arrival Inspections.**–Quarantine, customs, immigration, and agricultural quarantine officials are stationed in most major U.S. ports. (See appendix for addresses.) Vessels subject to such inspections generally make arrangements in advance through ships' agents. Unless otherwise directed, officials usually board vessels at their berths.

(134) **Harbormasters** are appointed for some of the principal ports. They have charge of enforcing harbor regulations, and in some instances are in charge of the anchorage and berthing of vessels.

(135) **Search and Rescue Telephone Number.**–(See this topic, chapter 1.)

(136) **Small-craft regulations, State of Michigan.**–The Marine Safety Act, Act No. 303, Public Acts of 1967, Michigan Compiled Laws states, in part:

(137) A person operating or propelling a vessel upon the waters of this State shall operate it in a careful and prudent manner and at such a rate of speed so as not to endanger unreasonably the life or property of any person. A person shall not operate any vessel at a rate of speed greater than will permit him, in the exercise of reasonable care, to bring the vessel to a stop within the assured clear distance ahead. A person shall not operate a vessel in a manner so as to interfere unreasonably with the lawful use by others of any waters.

(138) Persons operating vessels on the waters of this State shall maintain a distance of 100 feet (30.5 meters) from any dock, raft, buoyed or occupied bathing area, or vessel moored or at anchor, except when the vessel is proceeding at a slow-no wake speed or when water skiers are being picked up or dropped off, if such operation is otherwise conducted with due regard to the safety of persons and property and in accordance with the laws of this State.

(139) For purposes of this act, "Slow-no wake speed" means a very slow speed whereby the wake or wash created by the vessel would be minimal.

(140) In addition to the Marine Safety Act, the Law Enforcement Division of the Michigan Department of Natural Resources, in cooperation with local units of government, has established Special Local Watercraft Controls. These controls have been established in the interest of safety and to resolve conflicts of interest involving waterway usage. Speed limits contained in these regulations are described in the text.

(141) Additional information and copies of the Special Local Watercraft Controls and of Act 303 are available from the State of Michigan, Department of Natural Resources, Law Enforcement Division, Stevens T. Mason Building, Lansing, MI. 48933; telephone, 517-373-1230.

(142) **Small-craft harbors of refuge, State of Michigan.**–The Michigan State Waterways Commission, in conjunction with local municipalities, has constructed a series of small-craft harbors of refuge along the Michigan shorelines. The harbors are usually no more than 20 statute miles (17.4 nm) apart except on Lake Superior where they may be as much as 40 statute miles (34.8 nm) apart. The harbors, most of which are manned during the summer and equipped with VHF-FM channel 16, provide dockage and usually some services. These facilities are discussed in the text under **Small-craft facilities.**

(143) **Standard time**.–The area covered by this Coast Pilot is in two time zones, **Eastern standard time** and **Central standard time.**

(144) The boundary between Eastern standard time and Central standard time in the Great Lakes commences at the Lake Michigan shoreline intersection of the States of Michigan and Indiana, follows the northern boundary (which is offshore in Lake Michigan) of Indiana W to the W boundary (offshore in Lake Michigan) of Michigan, thence N along the Wisconsin-Michigan boundary (about midlake of Lake Michigan) to a point in about 45°15.2'N., 86°15.1'W., thence W along the Michigan-Wisconsin offshore boundary, passing between Rock Island, Wisc. and St. Martin Island, Mich., into Green Bay, thence to the Michigan shoreline in about 45°32.0'N., 87°16.2'W. (about 10 statute miles (8.7 nm) N of the mouth of Cedar River), thence along political boundaries (counties) to the Lake Superior shore of Michigan at about longitude 89°50.4'W. (about 10.3 statute miles (9 nm) NE of the mouth of Black River.) The boundary now proceeds W along the Michigan shore with the lakeshore areas within the Central standard time zone and the waters offshore within Eastern standard time zone to the Lake Superior shoreline intersection of the State boundary between Michigan and Wisconsin, thence about 024° following the offshore W boundary of the State of Michigan, crossing Lake Superior to the mouth of Pigeon River, the International boundary.

(145) Thus Eastern standard time (e.s.t.) is observed by the State of Michigan (except as noted below), the areas E of it, and the lakeshore areas of the Canadian Province of Ontario. Eastern standard time is 5 hours slow of Greenwich mean time (G.m.t.). Example: when it is 1000 at Greenwich it is 0500 at Detroit, Mich.

(146) Central standard time (c.s.t.) is observed in the Lake Michigan lakeshore areas of Indiana, Illinois, and Wisconsin, and the State of Michigan lakeshore areas on the W side of Lake Michigan as far N as about 10 statute miles (0.9 nm) N of the mouth of Cedar River. Now proceed to the N shore of Michigan's Upper Peninsular. Central standard time is observed from about 10 statute miles (0.9 nm) NE of Black River W to and through the lakeshore areas of Wisconsin and Minnesota. Central standard time is 6 hours slow of Greenwich mean time (G.m.t.). Example: when it is 1000 at Greenwich it is 0400 at Chicago, Ill.

(147) **Daylight savings time.**–Throughout the area of this Coast Pilot, clocks are advanced 1 hour on the first Sunday in

April and are set back to standard time on the last Sunday in October.

(148) **Legal public holidays.**–The following are legal public holidays in the U.S. areas covered by this Coast Pilot: New Year's Day, January 1; Martin Luther King, Jr.'s Birthday, third Monday in January; Washington's Birthday, third Monday in February; Memorial Day, last Monday in May; Independence Day, July 4; Labor Day, first Monday in September; Columbus Day, second Monday in October; Veterans Day, November 11; Thanksgiving Day, fourth Thursday in November; and Christmas Day, December 25. The national holidays are observed by employees of the Federal Government and the District of Columbia, and may not be observed by all the States in every case.

(149) Other holidays observed in the area of this Coast Pilot are: Martin Luther King Day, January 15 in Illinois, third Sunday in January in New York, and third Monday in January in Ohio; Lincoln's Birthday, February 12, Illinois, Indiana, Michigan, New York, Pennsylvania, and Vermont; Washington-Lincoln Day, third Monday in February, Ohio and Wisconsin; Town Meeting Day, first Tuesday in March, Vermont; Good Friday, Indiana and Wisconsin; Verrazano Day, April 7, New York; Minnesota Day, May 11, Minnesota; Flag Day, June 14 in Pennsylvania and second Sunday in June in New York; Bennington Battle Day, August 16, Vermont; Senior Citizens Day, fourth Sunday in September, Indiana; Francis Willard Day, September 28, Minnesota; Leif Ericson Day, October 9, Minnesota; General Pulaski Memorial Day, October 11, Indiana; and General Election Day, first Tuesday after the first Monday in November, Illinois, Indiana, New York, Pennsylvania, and Wisconsin.

(150) Holidays observed in the Canadian areas covered by this Coast Pilot are: New Years Day, January 1; Good Friday; Easter Monday; Victoria Day, Monday preceding May 25; Dominion Day, July 1; Civic Holiday, first Monday in August; Labor Day, first Monday in September; Thanksgiving Day, second Monday in October; Remembrance Day, November 11; Christmas Day, December 25; and Boxing Day, December 26.